July 1965

National Aeronautics and Space Administration

Semi-Annual Progress Report
NsG-394 Supplement 1

Reported on are the various project results to date supported under grant NsG-394 Supplement 1. In addition, the various activities (not of specific project type research) reported in the February 1965 semi-annual report have continued.

As indicated in the proposal submitted by Adelphi University in February 1965, some of the work reported on below is in its final stages, support for the work being transferred in some cases to the university and in some cases to other funding agencies. In addition, some of the work is now entering a new phase. Two papers have been presented as a result of partial support of the grant. One was given by Dr. Anthony Lemos at the American Physical Society Meeting in Kansas on "Two Dimensional Configuration Coordinate Diagrams for F-Centers", and the other, an invited paper on the general activities undertaken and the techniques used to support research in this program was given by Dr. Donald E. Cunningham at the American Association of Physics Teachers June meeting at the University of Tennessee. A text of the latter talk has been supplied to the Office of Grants and Research Contracts. The latter's content is more oriented to the mechanics of the program rather than the actual research results achieved.

The reports below are for the individual projects sufficiently far advanced to have achieved significant results. Three other projects are in their initial stages (and early results from one are included). These were described in the Adelphi proposal of February 1965. They are, "Effects of Low Temperatures and Magnetic Fields on Biological Materials", by Dr. R. Gillespie and Dr. R.W. Genberg; "Synthesis and Physical, Chemical Properties of New Metal - Coordinates with Acetylacetonates", by Dr. A. Vogel and Dr. S. Moon; and "Interaction of a Plasma with an External Field", by Dr. T. Morrone.

Research Project Results

a) Collision Processes in Gases - Dr. Donald E. Cunningham

The investigation of the coherent photon capture process has been extended to Hg^{198}. The analysis of the data already obtained for natural mercury has also continued.

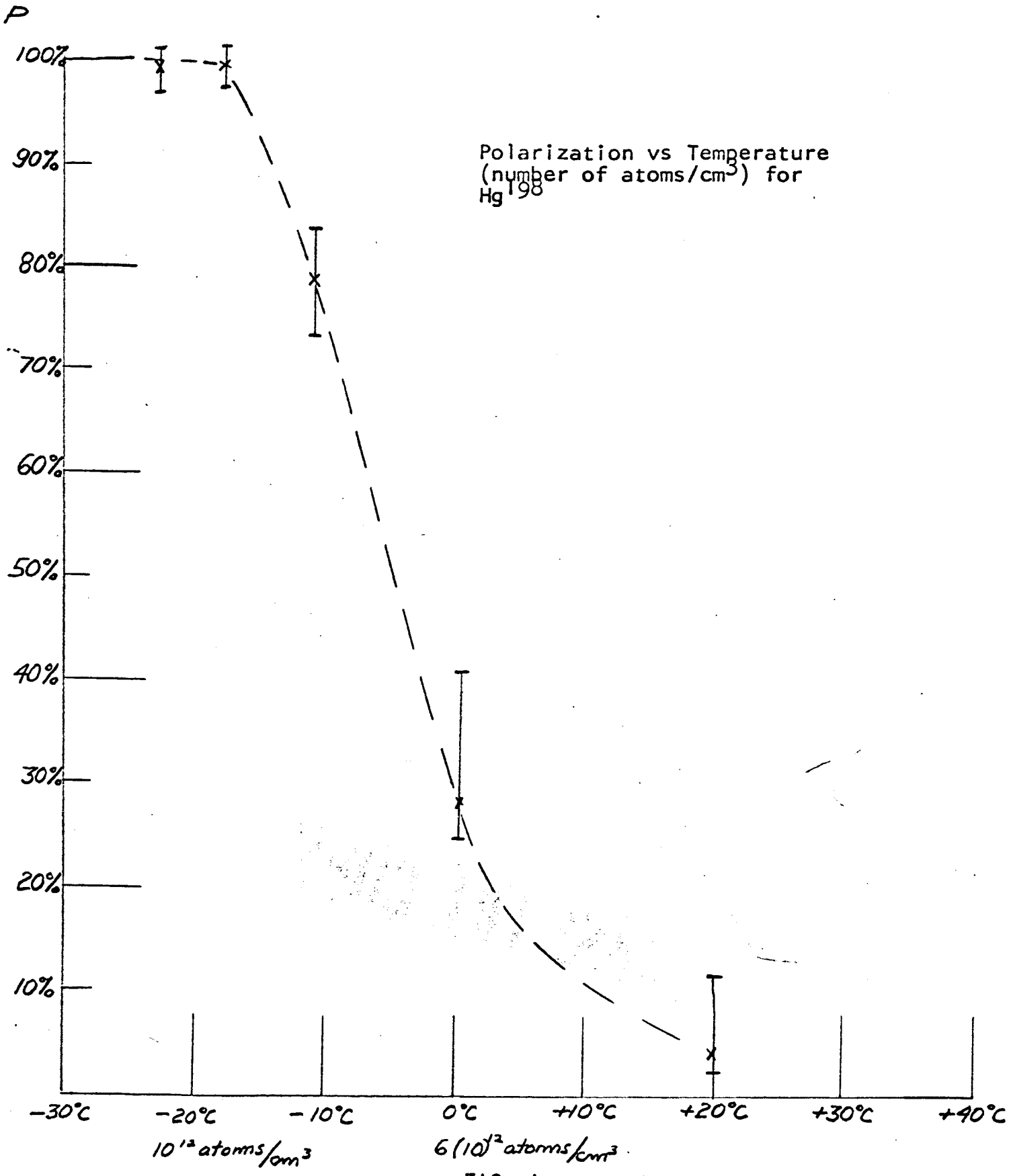
P
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
Polarization vs Temperature
(number of atoms/cm3) for
Hg198
-30°C
-20°C
-10°C
0°C
+10°C
+20°C
+30°C
+40°C
10^12 atoms/cm3
6(10)^12 atoms/cm3

FIG. 1

The "increase" in lifetime as a function of vapor (or number of atoms per cm^3) have been calculated in the natural mercury mixture. These range from the natural lifetime of 1.2 (10^{-7}) sec at vapor pressures corresponding to temperatures below -18^oC (approximately 10^{12} atoms/cm^3) to lifetimes of 2 (10^{-7}) sec at temperatures of -5^oC (or 4 (10^{12} atoms/cm^3). It has been possible to fit all the polarization vs. magnetic field data (the Hanlé method of determining atomic excited state lifetime) with a single value of excited state lifetime in spite of the fact that this single value lifetime varies by a factor of three as indicated above.

The same sort of data is being taken in Hg^{198}. Preliminary results are indicated in Figure 1. While there is a spread in data due to certain observational difficulties (which we now feel are overcome), it appears that the data is not inconsistent with the interpretation of the Hg^{198} isotope having the same lifetime as the natural mixture. This work will be continued and a complete analysis of the Hg^{198} data will be performed.

Apparatus also has been constructed to determine collision cross sections using the Hg^{198} data as baseline data. It is planned to study Argon initially and to measure cross sections as a function of vapor pressure.

b) Magnetic Susceptibility and Magnetothermal Oscillations in Beryllium - Dr. Richard W. Genberg

Variations in Magnetic Susceptibility

The physical preparation of the experiment has been undertaken in three distinct steps involving: 1. the crystal - selection, purification, cutting, x-ray mounting, etc.; 2. the production of a low temperature and controlled magnetic field region; 3. the torque sensing and data acquisition system. To date, effort in all three areas has been made with the greater concentration on the latter two.

Both a crystal cutter and zone refiner have been designed. The initial steps in the building of the zone refiner are underway. Further work in this area will be undertaken after the rest of the system is built and its performance evaluated.

The second step has essentially been completed. The magnetic field and the associated Hall probe have been calibrated. The desired field drive voltage profile has

been computed which will be used to sweep the magnetic field such that 1/H is linear in time. Sweeping the field in this manner will increase the overall sensitivity of the detection system and greatly facilitate the analyzing of the data. The device which will supply the desired voltage profile is presently under consideration.

A low temperature dewar has been mounted on rails so that it can be withdrawn from between the magnet pole pieces when necessary. In order to evacuate the dewar chambers and pump on the liquid helium (to lower the temperature) a pumping system has been constructed which contains the necessary vacuum gauges for monitoring the pressure. A pressure as low as 6×10^{-6} mm for Hg. has been attained in the dewar chambers.

The third area of effort represents the most difficult and important aspect of the apparatus. The detection system[1] has been designed and described in a previous report. The torque-sensing system is a null-detection system which consists of a photocell, amplifier, galvanometer and recorder. From the highly sensitive Leeds and Northrup galvanometer is suspended a long pyrex rod to which are attached the metal specimen and a shadow-casting couple. The galvanometer itself has been constructed according to our specifications and further modified: the lower portion has been cutaway and the galvanometer assembly shortened. Since the pyrex rod and sample hang from the galvanometer's 0.0015-inch copper wire, weight becomes a major consideration. The system has been hung and the weight problem apparently solved.

As the crystal tends to rotate under the effects of the magnetic field a narrow shadow starts to move across the photocell. The signal from the cell is sent to a d.c. differential amplifier. The output from the amplifier is used to drive the galvanometer producing a null-detection system. The amplifier has been built and made operational. The servo loop is presently being tested for sensitivity and response time.

Once the servo loop is completed, the signal to the galvanometer will be recorded as it will be proportional to the magnetic susceptibility. The system will be calibrated using a test crystal.

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[1] NASA Proposal - NsG-394 Supplement 1

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c. Reactions with 3Buten-1-ol and Phenethyl Alcohol With Lead Tetraacetate - Dr. S. Moon

The work on reaction mechanics in chemical bonding has continued. At present the reaction of 1 hexyne with lead tetraacetate has been studied rather completely. The products of the reaction have been separated and identified. The analysis has been performed by infrared spectra and nuclear magnetic resonance techniques.

As a result of the analysis it has been possible to assign structures to the reaction products. The structures so assigned have been compared with predicted structures which would occur if various reaction mechanisms had played the predominant role in the reactions. The predictions and resultant produced coincide if an ionic mechanism for the reaction is assumed.

d) Effects of Varying Physical Parameters on Post Irradiated Bacterial Cells - Dr. Concetta B. Cabral

The experimental organism used continues to be an auxotrophic strain of a bacterium, the tyrosine - requiring derivative of Escherichia coli, B/r, designated as strain WU 36, which yields ultraviolet-induced prototrophs; the test organism continues to be Escherichia coli, obtained from the Washington, D. C. Culture Collection.

Experiments were conducted relating to survival and mutational rates:

1) Survival rates on the tyrosine-deficient E. coli culture were estimated, the basic procedure involving exposure to ultraviolet light for one minute of the culture placed in dilution fluid, of which 0.1 ml samples were plated. Controls were conducted simultaneously, these differing only in the fact that they were not exposed to the ultraviolet source. Diverse methodology was tested until a procedure was adopted.

2) Auxotrophy-to-Prototrophy mutational rates on the tyrosie-deficient E. coli culture were likewise estimated, the basic procedure being as above except for the absence of the use of high dilutions undesirable here. Such rates were compared with the mean mutational rate of this nutritional mutant in the absence of exposure to an ultraviolet light source.

Experiments have also been conducted to determine the influence of alterations in the pH of the culture medium upon the cultural, morphological, and physiological characteristics of the auxotrophic strain in the absence of exposure to an ultraviolet source in order to accumulate comparative data to establish an explanation of similar or different results when the same techniques are applied as post-irradiation treatments.

Several variations in morphology, as compared with typical parental colonies have been noted, as: undulant margins instead of entire ones; appearance of so-called "football-shaped" colonies; changes in the size and shape of the rods including

the appearance of coccoid as well as long, filamentous colonies and cells. These alterations predominated at pH 5 and at pH 9. No notable modifications have been thus far derived with regard to the organism's ability to liquefy gelatin and/or to ferment various sugars.

Experiments also were carried out to determine the influence of incubation upon the auxotrophic strain in the absence of exposure to an ultraviolet source, in order to interpret future results when differences in temperature would constitute a post-irradiation treatment.

Now under investigation are the following problems: The study of those "intermediate" colonies which are neither resistant nor sensitive to the ultra-violet light source at wavelengths 2377 to 3022 Angstrom units and which increase in size, especially in length, without apparent inhibition, but which do not divide and therefore exceed the width and length of "normal" E. coli by many times; although the majority of these appear gradually to degenerate, some "normal daughter cells" have been observed to occur.

The method of measuring mutations by which the observation of mutant papillae on the surface of colonies, observed in these experiments and adapted successfully in the study of auxotrophy-to-prototrophy mutants (regarding which each papilla represents a mutation whose frequency can be increased by the application of a mutagenic agent such as an ultraviolet light source) will also be studied.

Studies will be undertaken to the "right timing" in the matter of applying the particular post-irradiation treatment since such treatments are believed to block RNA or protein synthesis and so should decrease the ultraviolet induced mutation frequency.

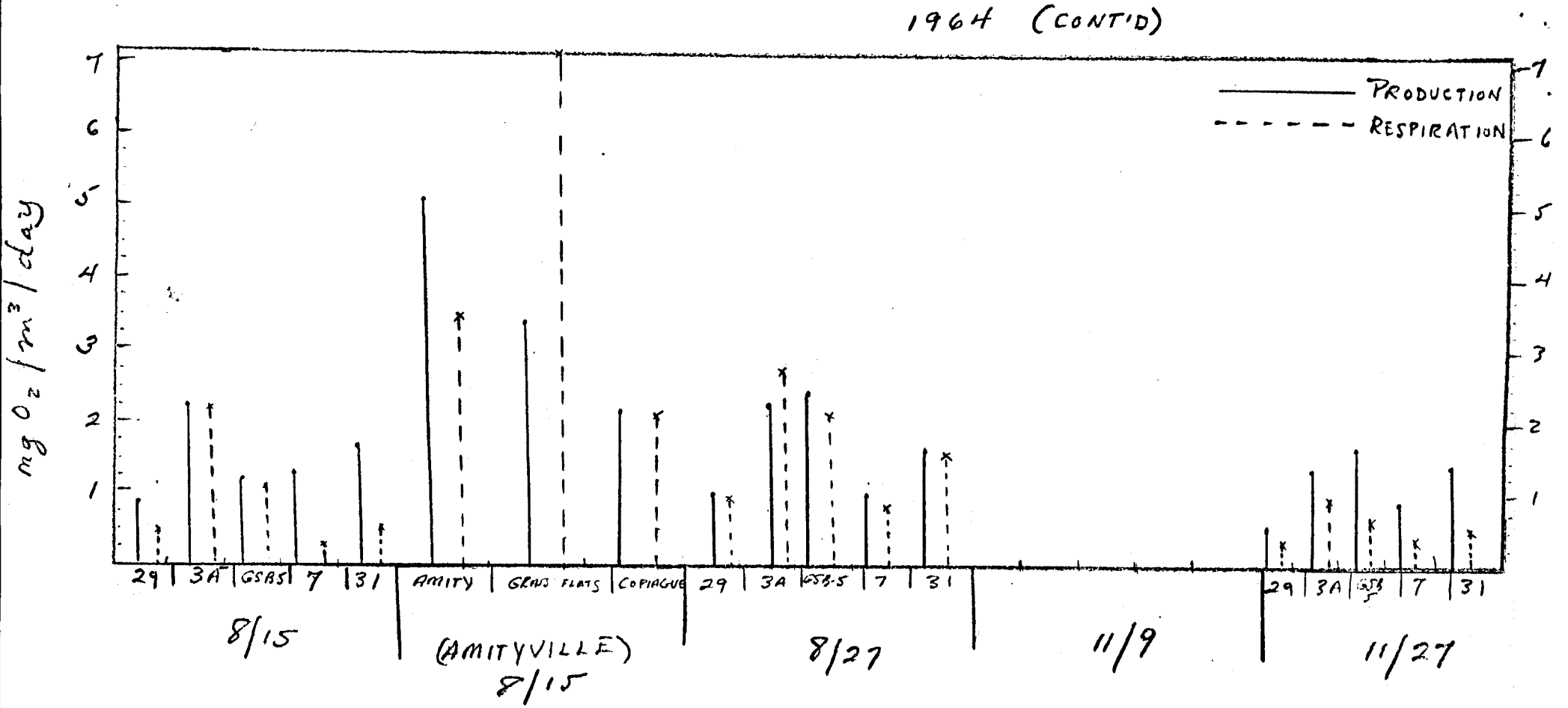
e) Studies of Interrelationships Between the Physical, Chemical, and Biological Components of Disturbed Estuarine Systems - Dr. H. Brenowitz and Dr. R. Wilson

The collected data is presented in the various graphs attached. Line graph 3 indicates that productivity in 1964 continued to be at a lower level than 1963 (refer to previous quarterly report). However, there were exceptions particularly at the Amityville station. Productivity continued during November, March and April, although dominant species changed and total populations were reduced in number.

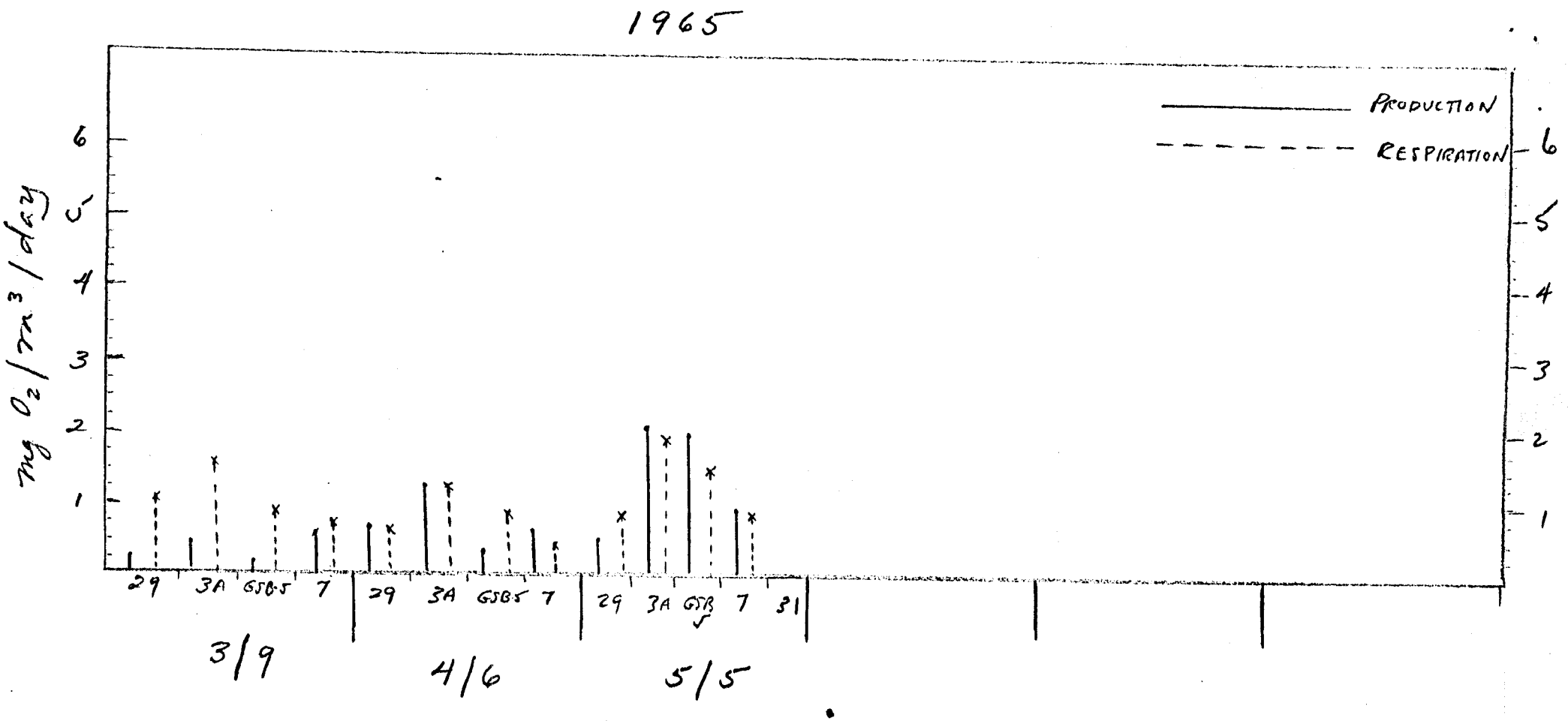
The increase in salinity in the estuary has apparently caused the changes in dominant species resulting in the overall decrease in productivity since 1963.

Productivity studies under controlled conditions are continuing. An attempt is being made to determine whether deviations from the planned environmental conditions in a controlled system will adversely affect the dominant producer organism and possibly destroy the entire system.

Figures 1, 2, 3, 4 and 5 report the total numbers/m^3 of copepods. All stations except 5 indicate a peak in early and late summer. This is quite contrary to reports for copepod populations in Long Island Sound, Rariton Bay, and oceanic waters. Copepod peaks usually follow February - March and September diatom blooms in the northern latitudes. The density of the copepod population maintained is relatively high, and the peak of over 600,000 /m^3 at station GSB5 in late August 1964 is unusually high.



LINE GRAPH 3 - Production - Respiration 1964 continued



LINE GRAPH 4 - Production - Respiration 1965

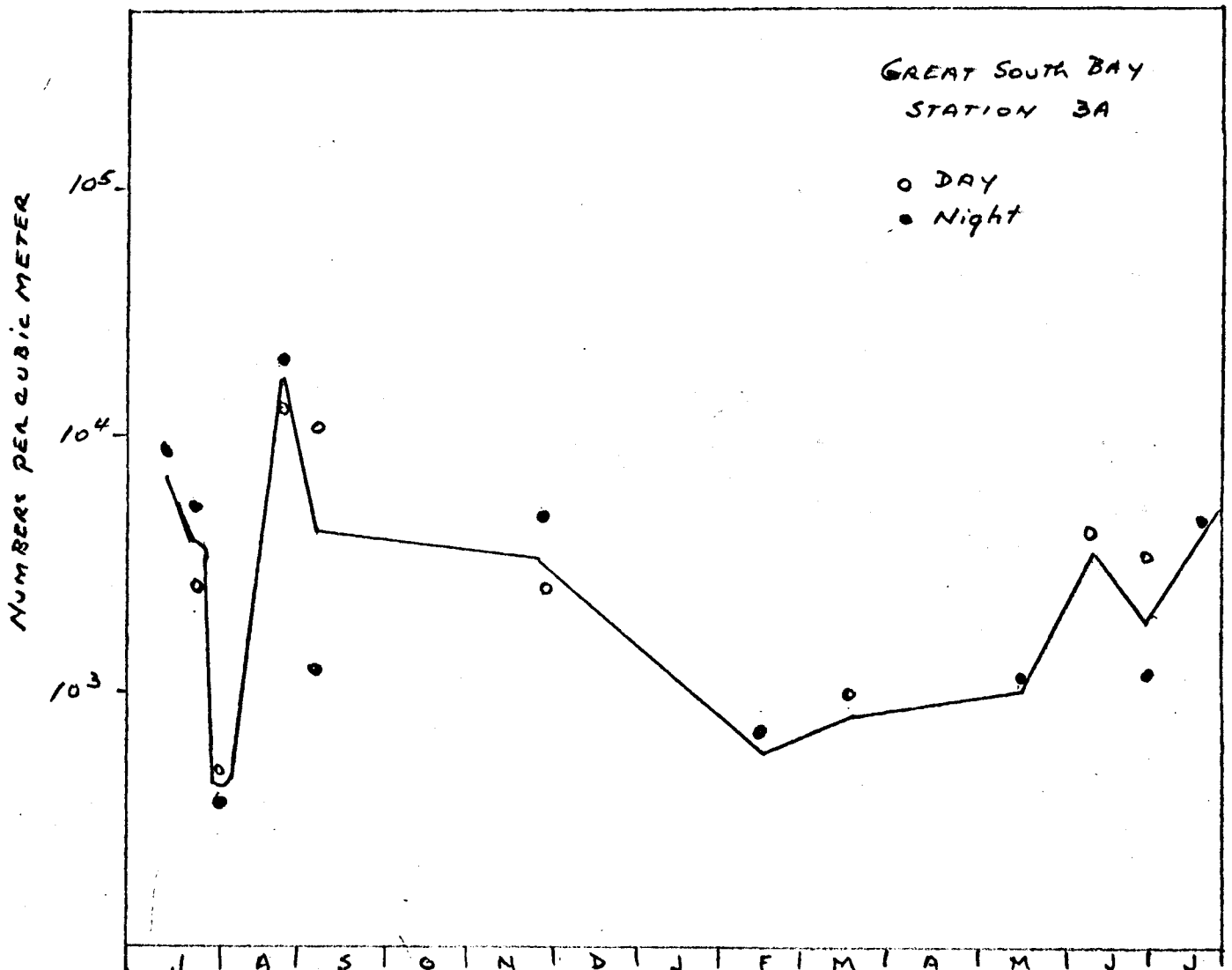


FIGURE 1. Total Numbers of Copepods #20 mesh Net

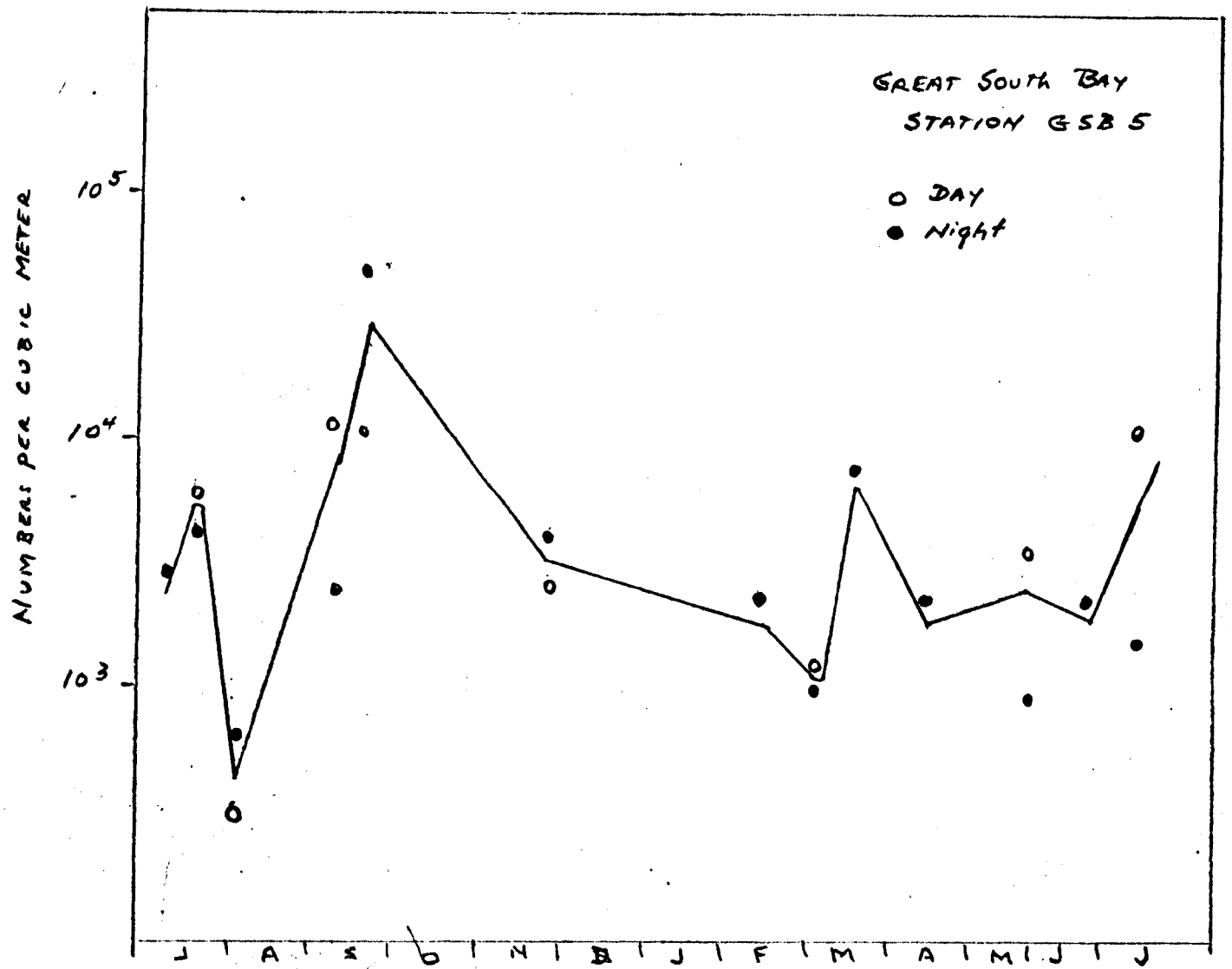


FIGURE 2. Total Numbers of Copepods #20 Mesh Net.

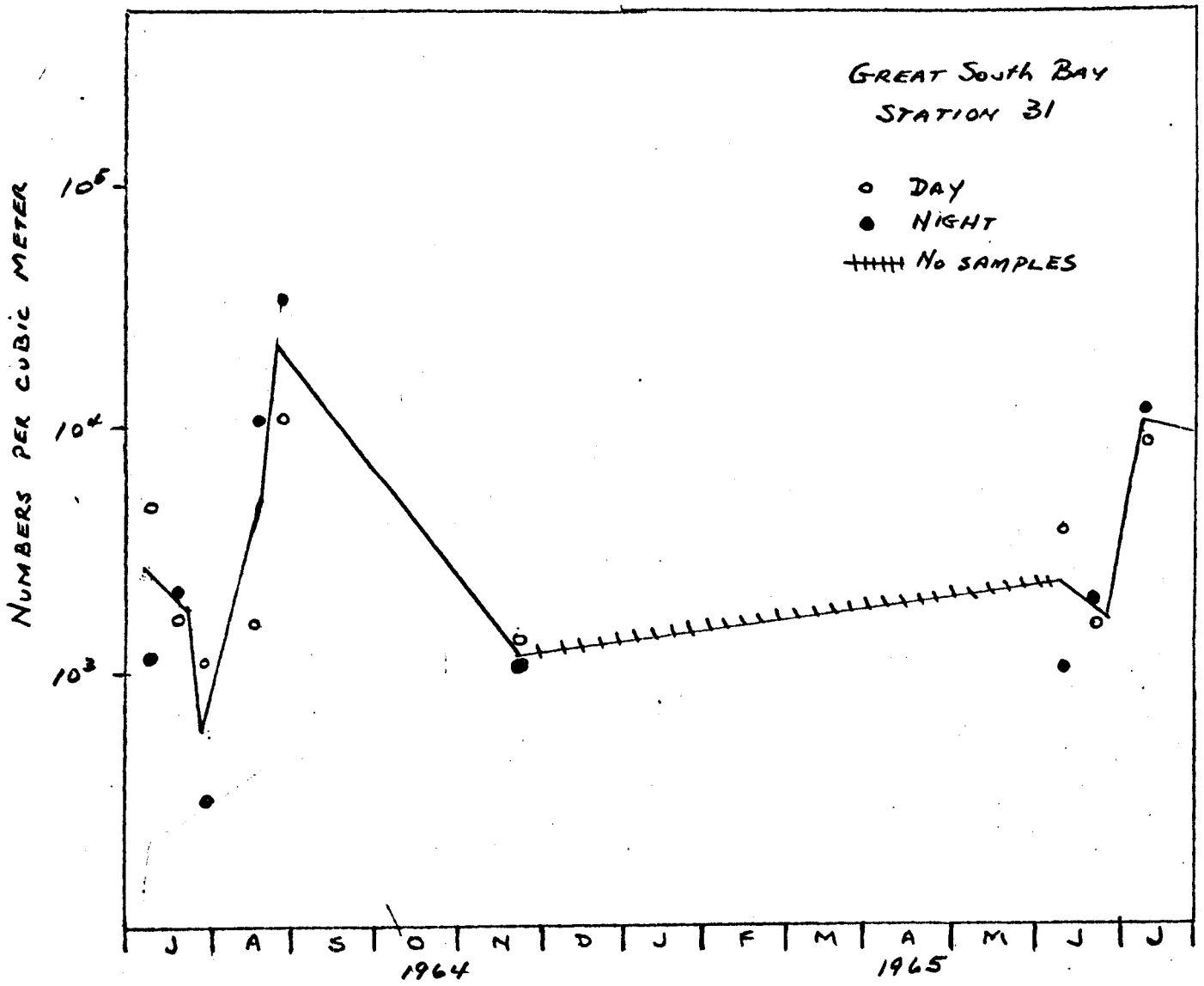


FIGURE 3. Total Numbers of Copepods #20 Mesh Net.

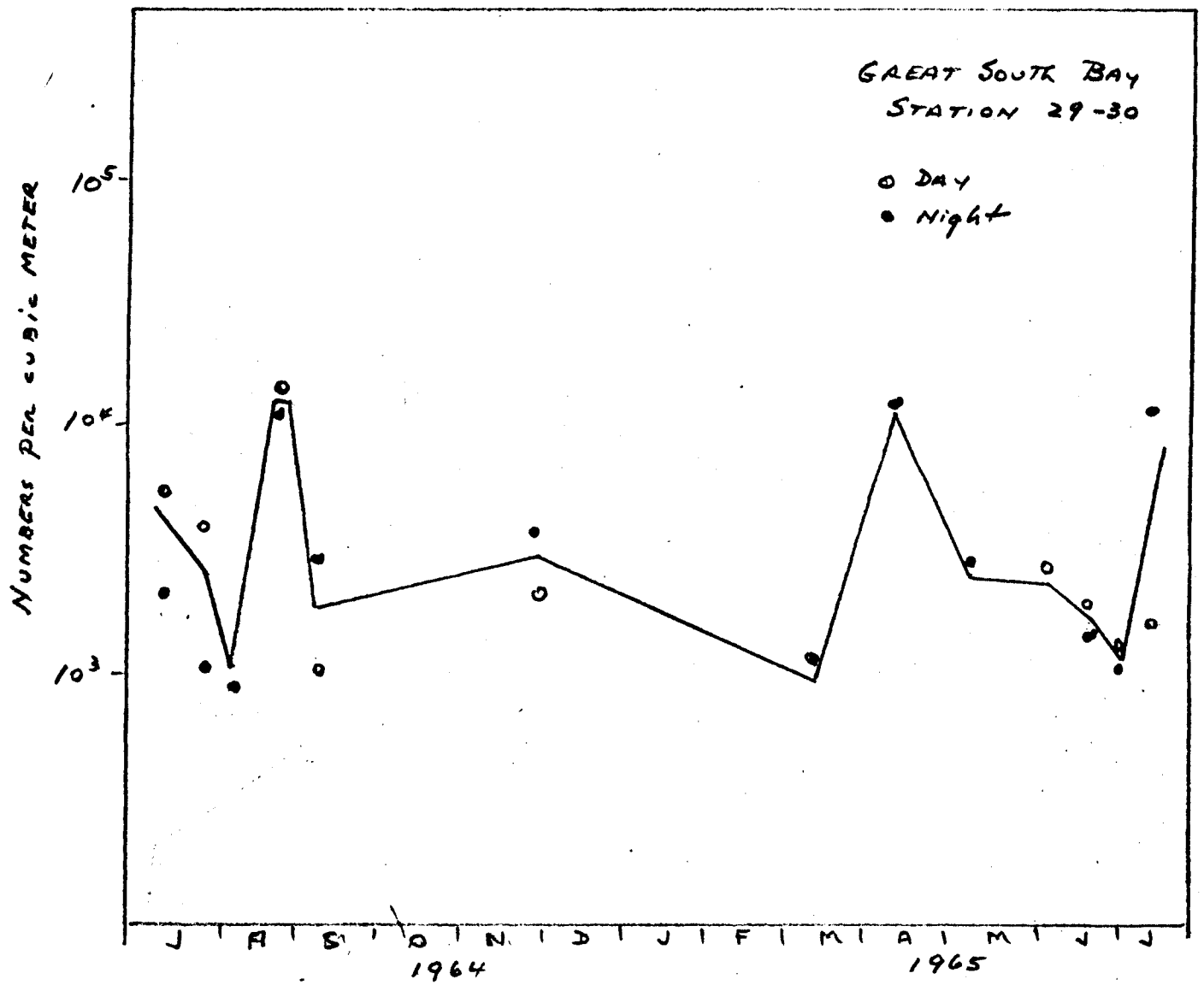


FIGURE 4. Total Numbers of Copepods #20 Mesh Net

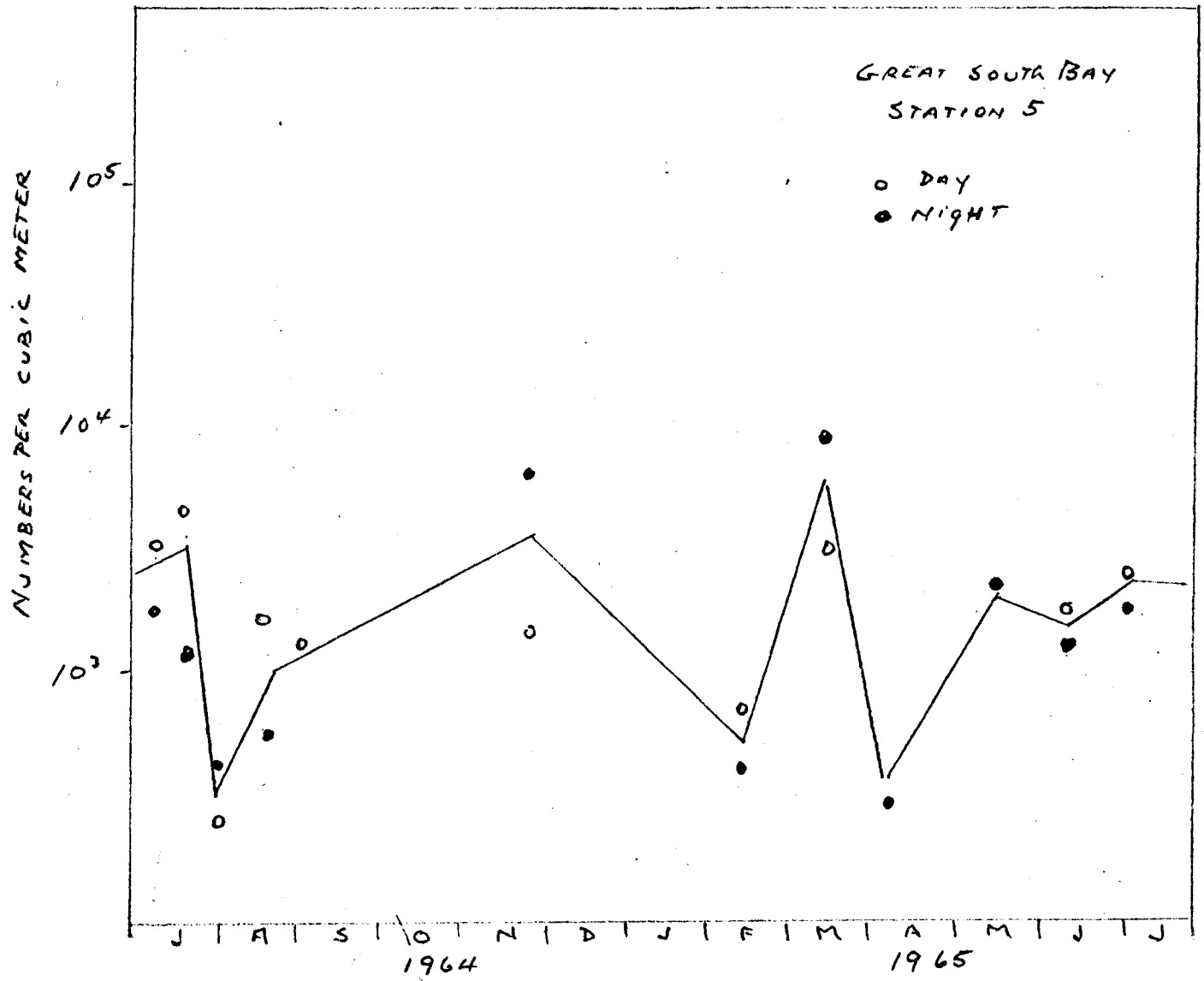


FIGURE 5. Total Copepods #20 Mesh Net.

f) Studies of Metal Solutions - Dr. S. Windwer

The research undertaken attempts the production of the tetramer of 1,2 dimethoxy methane. It has been used to dissolve alkali metals to yield metal solutions. The procedure outlined below has been used so far but indicates polymerization. Because of incomplete success, a multi-distillation of the tetramer in a closed evacuated system without using a strong drying agent is being attempted.

Redistillation of a fraction of the tetramer was tried off clean sodium ribbon. It was found that sodium increases the rate of polymerization even in a nitrogen atmosphere; because of this fact, sodium cannot be used as a drying agent for the tetramer.

A third preparation of the tetramer was made using 975 grams of propylene oxide and 25 grams of catalyst. A 225 ml. fraction of the tetramer was taken off a fractionating column at a head temperature of 90-94°C at 2 mm of mercury. This fraction had a slight pale yellow color to it, which is indicative of the presence of polymer.

A sample of this fraction was cooled with an acetone and dry ice bath. It was then placed under vacuum and oxide free potassium, which was sealed in the system, was poured into the tetramer. A bright blue color was noticable at the surface of the metal. This is indicative of the solavated electron system. The impurities in the tetramer caused hydrogen to be liberated. Instead of the solution becoming permeated with this blue color, it gradually darkened from pale yellow to a yellowish orange. This seemed to indicate an acceleration in the polymerization process. As the solution warmed up the rate of liberation of hydrogen had increased, indicating the expected temperature dependence.

The remaining aliquot of the tetramer was redistilled off a fractionating column at 1 mm of mercury. The distillate collected at 89-94°C had a slightly paler yellow coloration. It would seem that the rate of polymerization of the tetramer prohibits storage of the pure tetramer. A multi-redistillation of the tetramer in a closed evacuated system prior to addition of the alkali metal would be the proper method of purification.

g) Biochemical Studies of Polysaccharides - Dr. John Kiyasu

Although a number of anionic polysaccharides such as heparin or dextran sulfates are commercially available, polyphosphorylated polysaccharides have not been available or even notably used in polysaccharide chemistry. It is of

interest to synthesize polysaccharide polyphosphates of two different types: that containing phosphomonoester linkages, and that containing phosphodiester cross-linkages. The relationship to nucleo-protein complexes are somewhat suggested although the general problem of polymer-polymer interaction is itself a major problem.

The initial task of repeatedly synthesizing both starch polyphosphate and glycogen polyphosphate using $POCl_3$ and a variety of semi-anhydrous solvent systems has been undertaken. The product tends to be soluble even in 90% ethanol whereas the initial polysaccharide readily precipitates in 40% ethanol. Albumin, denatured by ethanol, can readily be redissolved by micro-quantities of this polysaccharide.

The general synthetic procedure established in our laboratory has been successfully used by Dr. F. Bettelheim (of our staff) for current studies which he is performing abroad on gel-filtration problems. Much of the work to date has been analytical such as determining, quantitatively, content of organic phosphate and reducing values. Since the polysaccharide polyphosphate preparation is still heterogeneous in nature we are now devising refraction procedures involving re-isolation through its calcium salt derivative.

As noted in the earlier parts of this report, one other investigation is in its initial stages. This involves a supercooling and reheating experiment with test animals. The research is being jointly undertaken by the Biology and Physics departments with Dr. Ronald J. Gillespie (Biology) and Dr. Richard W. Genberg (Physics) as principle investigators.

To date, equipment has been assembled and calibrated which permits biological materials or animals to be cooled from room temperature to approximately -150°C at a rate varying from 1°C to up to 30°C per minute, depending on the mass. This apparatus utilizes liquid nitrogen as the cooling medium and either an electric element and/or diathermy coils for reheating.

Reference to Table I will show some of the preliminary results. At first, lower temperature ranges were approached at maximum rates 30°/min to +3.0°, 0.0°, -4.0° and around -8.0°C, respectively, and the animals reheated from each of these levels by an electric element, also at its fastest rate 24°/min.

When roaches were used and when they had been on a diet of laboratory chow and water as the drinking fluid, they were able to survive 100% from cooling to $-9^{o}C$. In another group, a temperature drop of $-60^{o}C$ proved fatal.

Animals which received antifreeze agents (in the drinking water) did not survive so well. Those receiving glycerol at 5% level showed only a 20% survival rate a week later, though all were alive after thawing. Higher levels of glycerol (at 10 and 15%) proved to be toxic. It may be that they are not able to metabolize this substance.

The group receiving 15% ethanol showed a slightly better survival rate (40%). Others now receiving higher levels of alcohol will subsequently be tested.

Roaches given 10% dimethyl sulfoxide showed good survival rates (100% at $-4^{o}c$), but as yet they have not been lowered to $-8^{o}C$.

Time studies are now being conducted and preliminary runs have been encouraging. Two different groups of insects with plain water and no antifreeze agents were lowered to $-4^{o}C$. The first groups were held there for 5 minutes and showed a 100% survival. The second group, kept at this temperature for 10 minutes, appeared to be dead on rewarming to room temperature, but eventually showed a 20% survival.

Mice and rats have been irradiated with 100,150 and 200 roentgens of gamma radiation and some of these (the mice) have been kept in a magnetic field of 950 gauss for over two weeks. Blood samples are being taken at intervals to assess the effects on the animals by alterations in the blood. Reference to Table II will show that while changes are taking place, it is too early to say whether they are due to radiation or magnetic flux. Difficulties with the small spaces between the pole faces of available magnets have severely limited the number of animals which can be tested.

Future work will investigate more thoroughly the various rates of temperature change and antifreeze levels. Equipment is now being obtained and assembled to start experiments on larger animals. Various methods of altering the temperature by using the vascular network as a cooling system are being considered. The physiological changes such as heart rate, pH, temperatureand perhaps respiratory rate and oxygen concentration that result from altering these physical parameters will be recorded and analyzed.

TABLE I

EFFECTS OF COOLING & REWARMING OF YOUNG (APPROX. 5 MONTHS) COCKROACHES ON VARIOUS REGIMENS

Animals	Number	Regimen lab chow plus	Time on Regimen (Days)	TEMPERATURE			METHOD of rewarming to room temp. (°C/min)	Rate of rewarming (°C/Min)	SURVIVORS			
				Rate of drop (°C/min)	Lowest temp. (°C)	Time at lowest temp (min.)			Immediately Moving	Immediately Crawling	7-10 Days later	% Survival
Cockroaches	5	water	always	30	+3	0	Electric element	24	5	5	5	100
Same group	5	"	"	30	0	0	"	24	5	5	5	100
" "	5	"	"	30	-4	0	"	24	5	5	5	100
" "	5	"	"	30	-9	0	"	24	5	4	4	80
" "	5	"	"	30	-60	0	"	24	0	0	0	0
Cockroaches	5	5% glycerol	7	30	+3	0	"	24	5	5	5	100
Same group	5	" "	7	30	0	0	"	24	5	5	5	100
" "	5	" "	7	30	-4.5	0	"	24	5	5	5	100
" "	5	" "	7	30	-8.1	0	"	24	5	3	1	20
Cockroaches	5	15% Ethanol	3	30	+2.5	0	"	24	5	5	5	100
Same group	5	" "	3	30	0.0	0	"	24	5	5	5	100
" "	5	" "	3	30	-4.0	0	"	24	5	5	5	100
" "	5	" "	3	30	-8.5	0	"	24	5	1	2	40
Cockroaches	5	Dimethyl 10% Sulfoxide	4	30	+3.0		"	24	5	5	5	100
Same group	5	" "	4	30	0.0	0	"	24	5	5	5	100
" "	5	" "	4	30	-4.0	0	"	24	5	5	5	100
" "	5	" "	4	30	-4.0	5		24	2	0	5	100
Cockroaches	5	Water	always	30	-4.0	5	"	24	5	5	5	100
Cockroaches	5	Water	always	30	-4.0	10	"	24	0	0	1	20
Cockroaches	5	"	"	6.0	-8	0	"	24	0	0	5	100
Cockroaches	5	"	"	2.8	-4	5	"	24	2	3	5	100
Cockroaches	5	"	"	2.0	-11	5	"	24	1	0	1	20
Cockroaches	5	20% Ethanol	14 days	10.0	+4	0	"	24	0	5	5	100
Same group	5	"	"	12.0	0.0	0	"	24	5	5	5	100
" "	5	"	"	12	-4	0	"	24	5	4	5	100
" "	5	"	"	17	-20	0	"	24	0	0	0	0

TABLE II

EFFECTS OF MAGNETIC FLUX AND IONIZING RADIATION ON THE BLOOD OF MICE

Animal	Number	Dietary regimen	Time on regimen	Treatment: Ionizing radiation (roentgens)	Treatment: Magnetic flux (gauss)	Blood Parameters: WHITE CELLS: Differential (%): agranular lymphocytes: lymphocytes	agranular lymphocytes: monocytes	granular: neutrophils	granular: eosinophils	granular: basophils	OTHER CHANGES: Weight changes (gms)	Remarks
Mice	1	Chow + Water	0	100	950	49	0	51	(0)	(0)	26.1	
			10			55	2	43	0	0	20.1 -6.1	
			14			63	11	24	0	2	25.3 +5.2	
			18			58	10	32	0	0	27.5 +2.2	
			22			53	12	35	0	0	25.5 -2.0	
			27			50	12	36	1	1	21.3 -4.2	
											24.5 +3.2	
"	1	"	0	150	950							Died (pm changes) (5 days)
"	1	"	0	200	950	64	0	36	(0)	(0)	23.9	
						52	0	48	0	0	19.0 -4.9	
						60	9	30	1	0	23.8 +4.8	
						48	10	42	0	0	25.0 +2.2	
						61	11	27	0	1	24.0 -1.0	
						52	12	33	0	1	23.9 -0.1	
											23.0 -0.9	
"	1	"	0	100								Died (normal at autopsy) 10
"	1	"	0	150		52	0	48	0	0	22.4	
			10			53	0	47	0	0	24.5 +2.1	
			18			68	3	28	0	1	24.5 0.0	
			22			69	3	28	0	0	29.5 +5.0	
						68	2	30	0	0	28.0 -05	
"	1	"	0	200		45	0	55	0	0	23.9	
			10			43	3	54	0	0	19.3 -4.6	
			18			66	2	31	0	1	21.0 +1.7	
			22			75	2	23	0	0	21.5 +0.5	
						64	2	34	0	0	28.2 +6.7	